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Gianluca Rigatelli, MD, PhD, EBIR, FACC, FESC, FSCAI

Cardiovascualar Diagnosis and Endoluminal Interventions Unit, Rovigo General Hospital, Italy

Computed Flow Dynamic in Interventional Cardiology: Comparison of different optimization techniques in left main stenting

Why Computed flow dynamic?

Question:

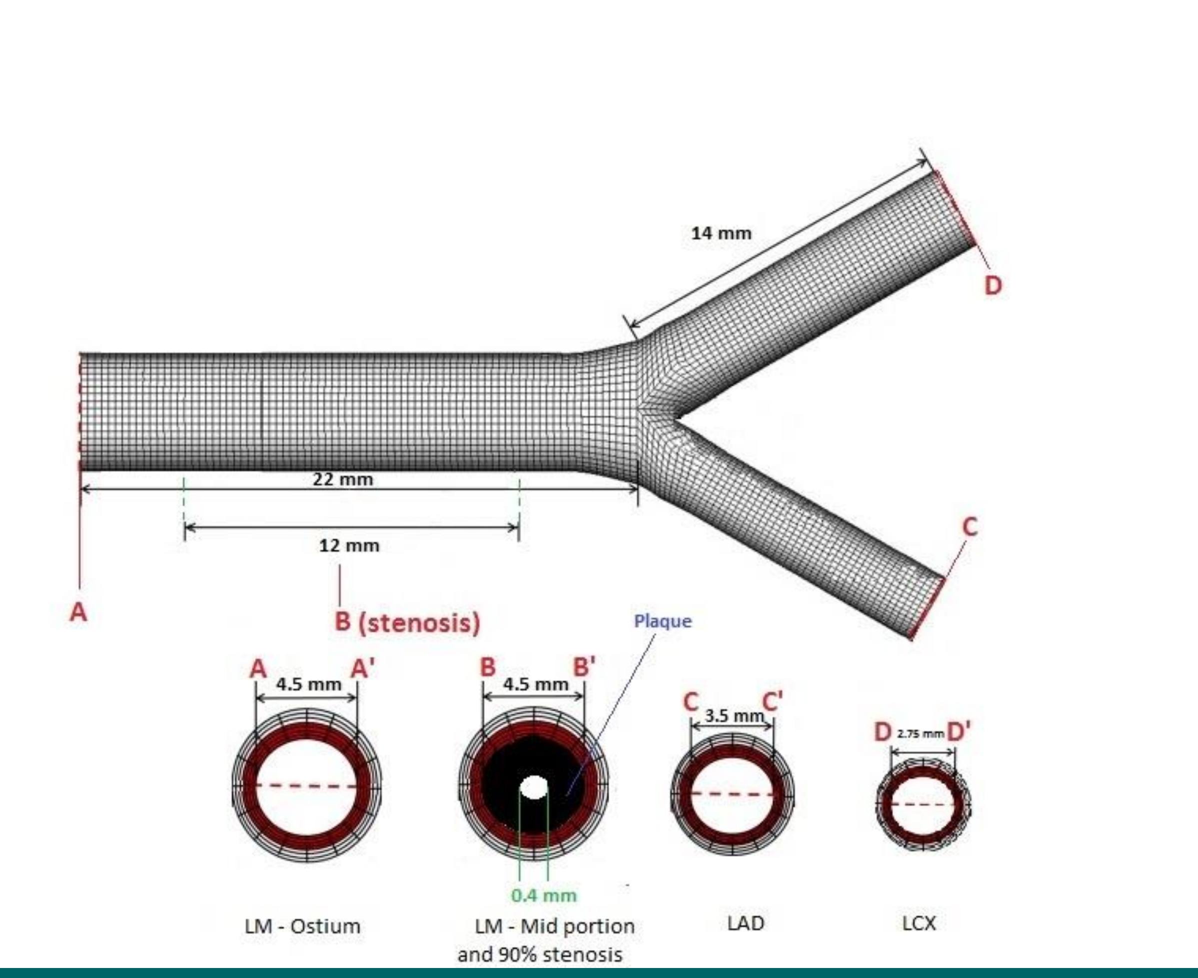
1. What is the best optimization technique in left main cross over stenting?

2. What is the best optimization technique in Left main dual stenting technique (Culotte)

CFD might be a type of answer….

Computed flow dynamic in Left Main

Coronary Left Main Model



Computed flow dynamic in coronary Left main

Considered fluid parameters

+ / -

Absolute number

- Static pressure (Pa)
- Reynolds number
- Vorticity magnitude (1/s)
- Stream function (Kg/s)
- Strain rate (1/s)
- Skin friction coefficient

- / +

physiology

WALL SHEAR STRESS: HIGHER VALUES ARE BETTER

Computed flow dynamic in coronary Left main

Stent simulation

the strut design and linkage pattern of a third-generation, everolimus-elunting stent (Orsiro stent, Biotronik IC, Bulack, Switzerland), used in our institution. In particular, the strut thickness is characterized by a very ultrathin strut (60 µm up to 3.0 mm diameter stent and 80µm up to 4.0 mm stent)

Virtual implantation

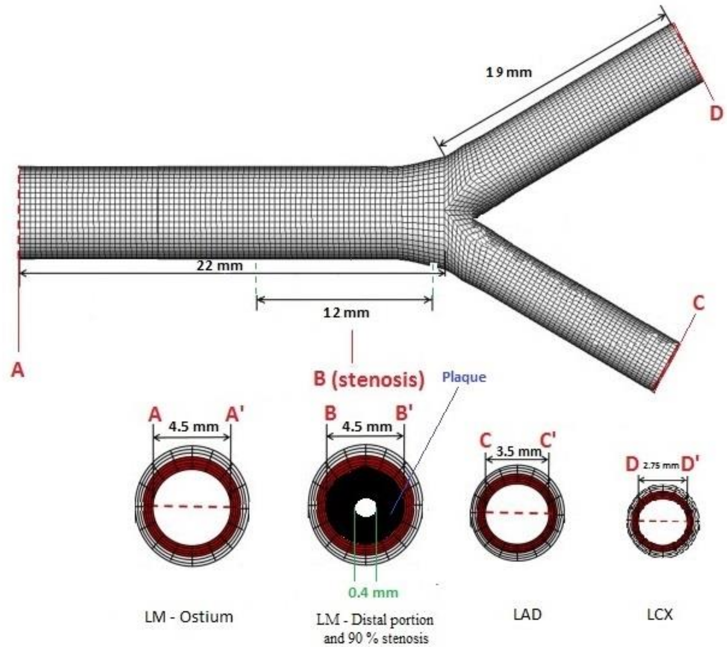
After placed the stent model in the correct position, according to the different stenting techniques, material removal, depending on the considering techniques was applied.
Using Boolean operation, the modified solid model is subtracted from the bifurcation model to obtain the final geometry

Computed flow dynamic in coronary Left Main

Virtual implantation Steps

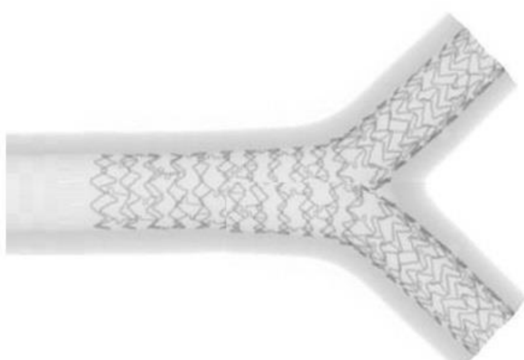
A-Cross-over/provisional stenting:
1) Predilation of MV 1:1 with non-compliant balloon; 2) Stenting of MV with stent diameter according to the distal MV reference diameter as currently recommended .

B- Culotte stenting:
1) Predilation of both branches 1:1 with non-compliant balloon; 2) Stenting of MV to SB; 3) Opening the stent cell with small 2.0 x 15 balloon; 4) Stenting MB proximal to distal

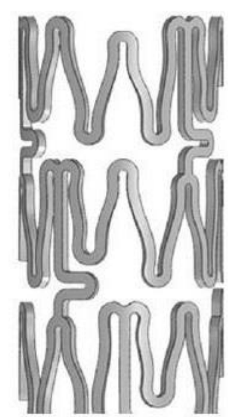

19 mm
D
22 mm
12 mm
C
A
B (stenosis)
Plaque
A
4.5 mm
A'
B
4.5 mm
B'
C
3.5 mm
C'
D
2.75 mm
D'
0.4 mm
LM - Ostium
LM - Distal portion
and 90 % stenosis
LAD
LCX

A

B



C



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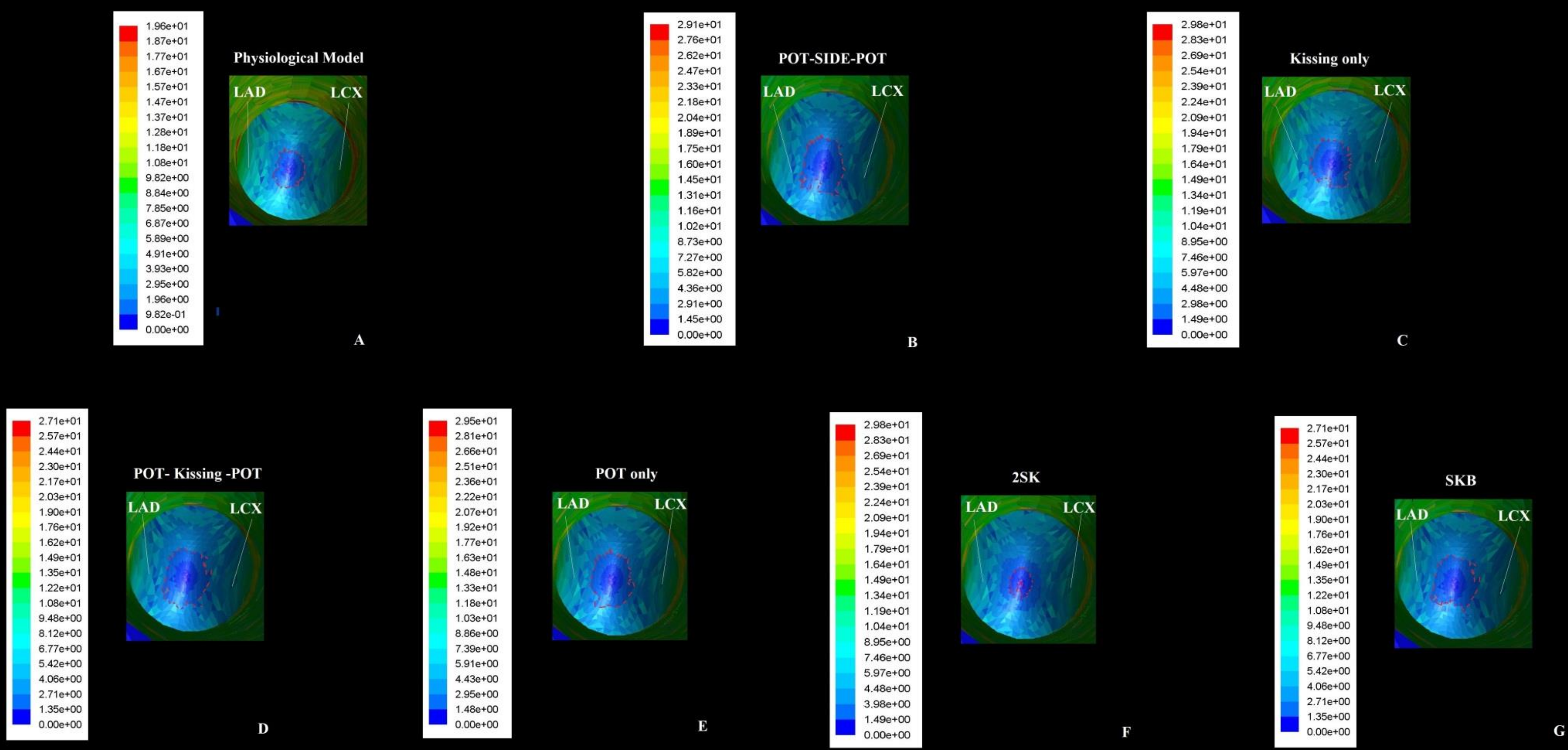
Techniques	Steps 1	2	3
POT	Inflation of SC balloon 4.5 x 6 mm at 20 atm		
KB	Inflation of the SB with SC balloon 2.0 x 15 mm at 16 atm	Simultaneous inflation of 3.5 x 15 (LM to LAD) e 2.75 x 15 mm (LM to LCx) SC balloons at 18 atm	
POT -Side-POT	Inflation of SC balloon 4.5 x 6 mm at 20 atm	Inflation of 2.75 x 15 mm (LM to LCx) NC balloon at 18 atm	Inflation of SC 4.5 x 6 mm balloon at 20 atm
POT-KB-POT	Inflation of SC balloon 4.5 x 6 mm at 20 atm	Simultaneous inflation of 3.5 x 15 (LM to LAD) e 2.75 x 15 mm (LM to LCx) SC balloons at 18 atm	Inflation of SC balloon 4.5 x 6 mm at 20 atm
2SK	Inflation of the SB with SC balloon 2.0 x 15 mm at 16 atm	Inflation of 3.5 x 15 (LM to LAD) SC balloon at 18 atm	Inflation of 2.75 x 15 mm (LM to LCx) SC balloon at 18 atm
SKB	Simultaneous inflation of 3.5 x 15 (LM to LAD) e 2.75 x 15 mm (LM to LCx) SC balloons at 18 atm with the marker of the SB balloon at the middle of the MB balloon		

Provisional stenting

	Pressure at the carena (mmHg)	WSS LAD (Pa)	WSS LCX (Pa)	WSS Carena (Pa)	Area of lower WSS at carena (mm2)	WSS opposite to the carina (Pa)	Area of lower WSS opposite to the carina (mm2)
Physiological Model	80 *	10.624* **	12.803*	3.266*	201* ** ***	2.28* **	186 * **
POT-Side-POT	79.2	9.210	10.657	2.740	508 **	2.96 **	304 **
KB only	80.8	10.407	12.06	3.100	254	3.02	214
POT-KB-POT	79.3*	8.415*	9.729*	2.503*	489*	2.44*	288 *
POT only	79.5	9.608	11.12	2.860	278	2.52	201
2SK	79.4	9.665	11.99	3.025	233	2.19	218
SKB	79.3	.897**	9.554 **	2.478 **	471 ***	3.58	265

Computed flow dynamic in coronary Left Main

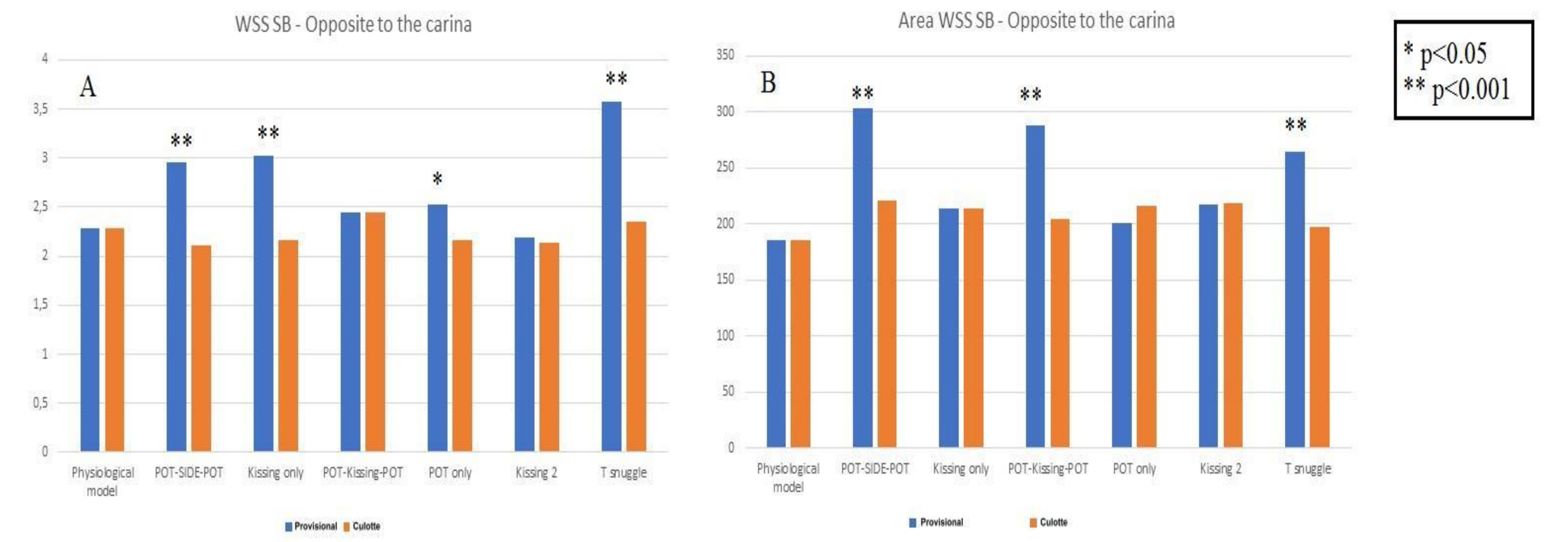
Provisional stenting



Culotte stenting

	Pressure at the carena (mmHg)	WSS LAD (Pa)	WSS LCX (Pa)	WSS Carena (Pa)	Area of lower WSS at carena (mm2)	WSS opposite to the carina (Pa)	Area of lower WSS opposite to the carina (mm2)
Physiological Model	80.0	10.624* **	12.800* **	3.266* **	208* **	2.28	186
POT-Side-POT	80.2	10.150	12.324*	3.102	249 **	2.11	221
KB only	80.2	10.204	12.477	3.189	236*	2.16	214
POT-KB-POT	79.9	10.769	12.698	3.403*	220	2.45	205
2SK	79.8	10.125*	12.355	3.279	228	2.14	219
SKB	79.8	9.995**	12.239**	3.104**	209	2.35	198

Computed flow dynamic in coronary Left Main



Computed flow dynamic in coronary Left Main

Answer

-in LM provisional stenting, POT, Kissing Balloon, and 2-SK showed a similar beneficial impact on the bifurcation rheology at both carena and SB wall opposite to the carena

-in LM Culotte stenting, POT-Kissing balloon-POT and Snuggle Kissing performed slightly better than the other techniques, probably reflecting a better strut apposition.

CONCLUSIONS….

- ✓Awaiting for clinical studies, CFD GIVE AT LEAST AN IDEA OF HOW MUCH THE INTERVENTIONAL TECHNIQUES ARE ADHERENT TO PHYSIOLOGY
- ✓APPLYING ONE OR ANOATHER TECHNIQUES HAS A DIFFERENT IMPACT ON RHEOLOGY
- ✓BY CFD POT and 2-SK RESULTED MORE BENEFICIAL IN CROSS OVER STENTING THAN OTHER TECHNIQUES
- ✓BY CFD POT-KB-POT AND 2-SK RESULTED MORE BENEFICIAL THAT OTHER TECHNIQUES IN DUAL STENTING probably reflecting a better struts apposition